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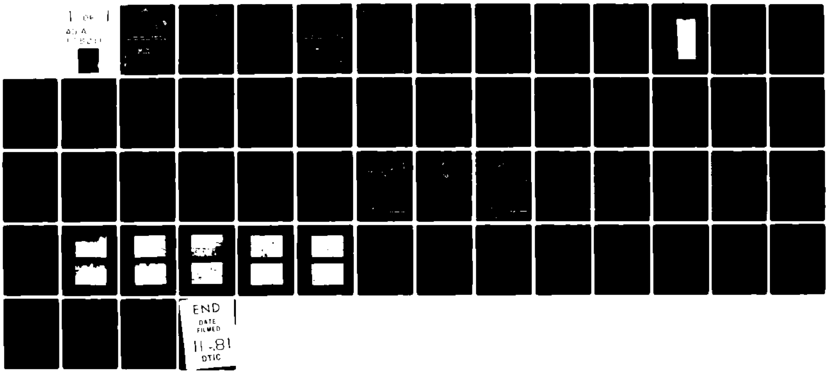

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BOONETRAIL FARM LAKE DAM

WARREN COUNTY, MISSOURI

MO 30511

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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UPPER MISSISSIPPI - SALT - QUINCY BASIN

BOONETRAIL FARM LAKE DAM

WARREN COUNTY, MISSOURI

MO 30511

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

LMSED-P

SUBJECT: Boonetrail Farm Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Boonetrail Farm Lake Dam (MO 30511):

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

2) Overtopping of the dam could result in failure of the dam.

3) Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED — Chief, Engineering Division — Date: 19 SEP 1980

APPROVED BY: SIGNED — Colonel, CE, District Engineer — Date: 22 SEP 1980

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BOONETRAIL FARM LAKE DAM

MISSOURI INVENTORY NO. 30511

WARREN COUNTY, MISSOURI

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

SEPTEMBER 1980

HS-8011

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Boonetrail Farm Lake Dam
State Located:	Missouri
County Located:	Warren
Stream:	Indian Camp Creek
Date of Inspection:	30 May 1980

Boonetrail Farm Lake Dam was visually inspected by engineering personnel of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of this inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the dam poses a hazard to human life or property.

~~The following~~ summarizes the findings of the visual inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based on the visual inspection and the results of these hydrologic/hydraulic investigations, the present general condition of the dam is considered to be less than satisfactory. The following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam:

1. A heavy growth of brush and small-to-medium sized trees exist on the downstream face of the dam. Numerous small trees and some brush were also found on the upstream face of the dam. Tree roots can provide passageways for lake seepage which could

develop into a piping condition (progressive internal erosion) that may result in failure of the dam. Brush can conceal animal burrows which could also provide passageways for lake seepage.

2. Erosion, presumably by wave action, has created a near vertical bank which varies from about 2 feet to approximately 4 feet in height along the upstream face of the dam. Loss of section by erosion can impair the structural stability of the dam.

3. An area of seepage with soft ground and standing water was observed to the left of the center of the dam, near the toe of slope. Uncontrolled seepage could develop into a piping condition that can lead to failure of the dam.

4. The dam, according to survey data obtained during the inspection, appears to have settled, on the order of 1.0 foot, in the vicinity of the original stream crossing, and the top of the dam near the left abutment was found to be considerably lower, about 1.5 feet, than the dam crest at the center of the structure. Low areas in the dam crest reduce freeboard and penalize spillway capacity.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the Boonetrail Farm Lake Dam, which is classified as small in size and of high hazard potential, is specified to be a minimum of one-half the Probable Maximum Flood (PMF). Considering the fact that a main line railroad track and an interstate highway are located within the possible flood damage zone less than one-half mile downstream of the dam, it is recommended that the spillway for this dam be designed for the PMF. The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The PMF is ordinarily accepted as the inflow design flood for dams where failure of the structure would increase the danger to human life.

Results of a hydrologic/hydraulic analysis indicated that the spillway is inadequate to pass lake outflow resulting from a storm of PMF magnitude. The spillway is capable of passing lake outflow resulting from the one percent chance (100-year frequency) flood and the outflow corresponding to about 33 percent of the PMF. According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, is estimated to be five miles. Accordingly, within the possible damage zone are a main line railroad track, Interstate Highway I-70, two house trailers, a dwelling and three county roads.

A review of available data did not disclose that seepage or stability analyses of this dam were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action without undue delay to correct or control the deficiencies and safety defects reported herein.

Ralph E. Sauthoff

Ralph E. Sauthoff
P. E. Missouri E-19090

Albert B. Becker, Jr.

Albert B. Becker, Jr.
P. E. Missouri E-9168

OVERVIEW BOONETRAIL FARM LAKE DAM

PHASE 1 INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

BOONETRAIL FARM LAKE DAM - MO 30511

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PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

BOONETRAIL FARM LAKE DAM - MO 30511

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the Boonetrail Farm Lake Dam be made.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the dam with respect to safety and, based upon available data and this inspection, determine if the dam poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams," Appendix D to "Report to the Chief of Engineers on the National Program of Inspection of Non-Federal Dams," dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Boonetrail Farm Lake Dam is an earthfill type embankment rising approximately 28 feet above the original streambed. The embankment has an upstream slope (above the waterline) of approximately 1v on 1.8h, a crest width of about 13 feet, and a downstream slope which varies from about 1v on 2.9h to nearly 1v on 3.3h. The

length of the dam is approximately 915 feet. A plan and profile of the dam are shown on Plate 3 and a cross-section of the dam is shown on Plate 4. At normal pool level the reservoir impounded by the dam occupies approximately 26 acres. The inspection did not reveal the presence of a lake drawdown facility.

The spillway, an earthen trapezoidal section, is cut through the hillside at the left, or north, abutment. The spillway outlet channel is an excavated section with an earth bank constructed on the downhill, or right, side to confine flow to the channel. The channel discharges to an eroded ditch at a point approximately 180 feet from the centerline of the dam. The eroded channel joins the original stream on which the dam was constructed at a point approximately 600 feet downstream of the dam. A profile of the spillway channel along the centerline of the invert is shown on Plate 4 and a cross-section of the channel at the crest location is presented on Plate 5.

b. Location. The dam is located on Indian Camp Creek, about one mile southwest of the junction of Interstate Highway I-70 and Strack Church Road, approximately three miles east of Warrenton, Missouri, as shown on the Regional Vicinty Map, Plate 1. The dam is located in the southwest quadrant of Section 25, Township 47 North, Range 2 West, within Warren County.

c. Size Classification. The size classification, based on the height of the dam and storage capacity, is categorized as small. (Per Table 1, Recommended Guidelines for Safety Inspection of Dams.)

d. Hazard Classification. Boonetrail Farm Lake Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that if the dam should fail, there may be loss of life, serious damage to homes, or extensive damage to agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis District, extends five miles downstream of the dam. Within the possible damage zone are a main line railroad track, Interstate Highway I-70, two house trailers, one dwelling, and three county roads. Those features lying within the downstream damage zone as reported by the St. Louis District, Corps of Engineers, were verified by the inspection team.

e. Ownership. The lake and dam are owned by the Material Hauling Company, Route 1, Box 158, Hazelwood, Missouri, 63042. Mr. Edward Viehmann is the President of the Material Hauling Company.

f. Purpose of Dam. The dam impounds water for recreational use.

g. Design and Construction History. According to Mr. David Bangert, a representative of the Owner, the dam was constructed in about 1956. Mr. Bangert reported that at that time, a Mr. George Sutton was the Owner of the property. The present whereabouts or status of Mr. Sutton are unknown. The extent of the engineering investigations performed for design of the dam or the contractor that built the dam are also unknown.

h. Normal Operational Procedure. The lake level is unregulated. Lake outflow is governed by the capacity of an excavated earth spillway.

1.3 PERTINENT DATA

a. Drainage Area. With the exception of some of the land in the vicinity of the lake which is used for pasture, the drainage area tributary to the lake is for the most part in a native state covered with timber. The watershed above the dam amounts to approximately 277 acres. The watershed area is outlined on Plate 2.

b. Discharge at Damsite.

(1) Estimated known maximum flood at damsite ... 29 cfs* (W.S. Elev. 805.0)

(2) Spillway capacity at maximum pool ... 733 cfs (W.S. Elev. 807.1)

*Based on an estimate of depth of spillway flow per Mr. D. Bangert, a representative of the Owner.

c. Elevation (Ft. above MSL). The following elevations were determined by survey and are based on the elevation of the lake, assumed to be the normal pool level, as shown on the 1972 Wright City, Missouri, Quadrangle Map, 7.5 Minute Series.

(1) Observed pool ... 804.0

(2) Normal pool ... 804.0

(3) Spillway crest ... 804.0

(4) Maximum experienced pool ... 805.0*

(5) Top of dam ... 807.1 (min.)

(6) Streambed at centerline of dam ... 782± (est.)

(7) Maximum tailwater ... Unknown

(8) Observed tailwater ... None

d. Reservoir.

(1) Length at normal pool (Elev. 804.0) ... 2,000 ft.

(2) Length at maximum pool (Elev. 807.1) ... 2,200 ft.

e. Storage.

(1) Normal pool ... 206 ac. ft.

(2) Top of dam (incremental) ... 89 ac. ft.

f. Reservoir Surface.

(1) Normal pool ... 26 acres

(2) Top of dam (incremental) ... 4 acres

*Based on an estimate of depth of spillway flow per Mr. D. Bangert, a representative of the Owner.

g. Dam. The height of the dam is defined to be the overall vertical distance from the lowest point of foundation surface at the downstream toe of the barrier to the top of the dam.

(1) Type ... Earthfill

(2) Length ... 915 ft.

(3) Height ... 28 ft.

(4) Top width ... 13 ft.

(5) Side slopes

a. Upstream ... 1v on 1.8h (above waterline)

b. Downstream ... Varies from 1v on 2.9h to 1v on 3.3h

(6) Cutoff ... Unknown

(7) Slope protection

a. Upstream ... Some logs and rubble

b. Downstream ... Grass

h. Principal Spillway.

(1) Type ... Uncontrolled, excavated earth, trapezoidal section

(2) Location ... Left abutment

(3) Crest ... Elevation 804.0

(4) Approach channel ... Lake

(5) Exit channel ... Earth, trapezoidal section

i. Emergency Spillway ... None.

j. Lake Drawdown Facility ... None known.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No engineering data relating to the design of the dam are known to exist.

2.2 CONSTRUCTION

No records of the construction of the dam are known to exist. As previously stated the dam was reported to have been constructed about 1956.

2.3 OPERATION

The lake level is uncontrolled, and governed by the elevation of the spillway crest. No indication that the dam had been overtopped was noticed during the inspection. Mr. David Bangert, a representative of the Owner, stated that to his knowledge the dam had never been overtopped and that the greatest depth of flow at the spillway that could be recalled was estimated to be about 1 foot.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the dam and spillway were unavailable.

b. Adequacy. No data available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity. No data available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the Boonetrail Farm Lake Dam was made by Horner & Shifrin engineering personnel, R. E. Sauthoff, Civil Engineer, and A. B. Becker, Jr., Civil and Soils Engineer, on 30 May 1980. An examination of the dam area was also made by an engineering geologist, Jerry D. Higgins, Ph.D., a consultant retained by Horner & Shifrin for the purpose of assessing the site geology. Also examined at the time of the inspection, were the areas and features below the dam within the potential flood damage zone. Photographs of the dam taken at the time of the inspection are included on Pages A-1 through A-5 of Appendix A. The locations of the photographs taken during the inspection are indicated on Plate 3.

b. Site Geology. The dam area is located near the southern edge of the Dissected Till Plains Section of the Central Lowlands Physiographic Province. The topography is gently rolling with 45 to 65 feet of relief between the lake site and the surrounding drainage divides. The bedrock formations consist of gently northward-dipping Mississippian-age limestones of the Osagean series. No bedrock outcrops were noted at the site; however, bedrock exposures in the general vicinity indicate the area is probably underlain by Burlington-Keokuk limestones. No faults were observed or are reported to be present in this area.

The Burlington-Keokuk formations are light gray to buff colored, coarsely crystalline, fossiliferous, crinoidal limestones. The limestones are medium-bedded and contain abundant chert in the form of layers and nodules. The formations are well known for solution-weathered features including sinkholes, caves, solution-enlarged joints or bedding planes, and a highly irregular bedrock surface. No evidence of these karst features was noted in the dam or reservoir area. The thick soil cover, common to this region, would tend to mask these features and minimize their effects on the performance of the reservoir and dam.

The bedrock is overlain by thick deposits of glacial till and loess. The principal soils at the site are the Keswick series consisting of deep, moderately well-drained soils formed from loess deposits. This series consists of dark grayish-brown silts which become darker and more clayey with depth. According to the Unified Soil Classification System, the soils are classified as CL or CL-ML materials, are low in permeability, and erode easily. Glacial till was noted underlying the Keswick soils downstream from the embankment. Although the till was not observed in the immediate vicinity of the reservoir or embankment, it is very probable that it overlies the bedrock at the lake site. The alluvial soils of the Dockery series are present along the stream channel, and most probably under the dam and reservoir. This series consists of stratified silts and clays classified as CL-ML or CL materials. These soils are often the cause of reservoir seepage and can be subject to piping.

The most significant geologic condition at the site is the susceptibility of the loessal soils to erosion. No other geologic conditions were observed that would be considered to adversely affect the performance of the reservoir or embankment.

c. Dam. The visible portions of the upstream and downstream faces of the dam (see Photos 1 and 2) as well as the dam crest were inspected and, except where damaged by erosion and as noted herein, appeared to be in sound condition. However, the downstream face of the dam could not be thoroughly examined due to the existence of dense brush and small-to-medium size trees on the slope. Numerous small trees and some brush were also present on the upstream face. Erosion of the upstream face of the dam, apparently due to wave action, has created an almost vertical bank above the normal waterline which varies from about 2 feet to approximately 4 feet in height. At some locations, cracks are apparent along the upstream edge of the crest, and some of the embankment material (see Photo 9) is beginning to crumble and slough away. No horizontal misalignment of the dam crest was noted. Large logs and some rubble (see Photos 7 and 8) had been placed at several locations along the upstream face of the dam to prevent erosion and protect the slope. An examination of the surficial material obtained from the downstream face of the dam indicated it to be a silty lean clay (CL) of low plasticity.

Based on survey data obtained during the inspection, it appeared that, in the vicinity of the original stream crossing, the dam had settled approximately 1.0 foot. However, the lowest portions of the dam crest were found to be near the left abutment where the crest was about 1.5 feet lower than the top of the dam at the center of the structure.

An area of seepage approximately 20 feet wide and 150 feet long was evident near the toe of the downstream slope. The area, which begins about 150 feet to the right of the left abutment, contained soft ground and standing water (see Photo 10).

The excavated earth spillway (see Photo 3) appeared to be in satisfactory condition and although the turf cover across the invert was sparse, only minor, insignificant erosion was noticed. Measures had apparently been taken to prevent erosion of the spillway outlet channel (see Photos 4 and 5). Rubble had been placed in the channel at several locations, and at four places concrete check dams about 3 inches high and one foot wide cross the channel invert. Approximately 230 feet downstream of the dam centerline, the outlet drops abruptly into a severely eroded channel (see Photo 6) about 10 feet deep. The channel had been partially filled with trash and debris, apparently in an attempt to prevent further erosion.

d. Appurtenant Structures. No appurtenant structures were observed at this dam site.

e. Downstream Channel. Except at the rail and road crossings, the downstream channel is unimproved. The channel section is irregular and for the most part lined with trees. The average slope of the channel for a distance of one mile downstream of the dam is approximately 1.5 percent. The channel is crossed by the Norfolk and Western Railroad about 700 feet downstream of the dam, and by Interstate Highway I-70 approximately one-half mile downstream of the dam.

f. Reservoir. The area adjacent to the lake is primarily in a natural state covered with a dense growth of trees. The shoreline is tree lined or grass covered. At the time of this inspection the lake was clear and at

normal pool level. Two small islands exist within the lake; one at the upstream end of the reservoir, and the other near the dam. The amount of sediment within the lake could not be determined at the time of the inspection; however, due to the vegetation covering the surrounding area, it is not expected to be significant.

3.2 EVALUATION

The deficiencies observed during the inspection, and noted herein, are not considered of significant importance to warrant immediate remedial action. However, it is recommended that, as soon as practical, the trees and brush be removed from the embankment as indicated in paragraph 7.2b(1), and that the entire downstream slope be re-examined after it is cleared for signs of seepage, erosion and other defects.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillway is uncontrolled. The lake surface level is governed by precipitation runoff, evaporation, seepage, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

According to Mr. David Bangert, a representative of the Owner, the grass on the dam crest is cut periodically through the growing season. Mr. Bangert also reported that the spillway was lowered approximately 18 inches about 12 years ago and that the logs along the upstream face of the dam were placed there at that same time in an effort to prevent erosion of the embankment.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

No outlet facilities requiring operation exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection did not reveal the existence of a dam failure warning system.

4.5 EVALUATION

Judging by the growth of trees and brush on the downstream face of the dam as well as the eroded condition of the upstream face of the dam, the inspection team is of the opinion that maintenance of the dam has been somewhat neglected.

Lack of or inadequate maintenance is considered detrimental to the safety of the dam. It is recommended that maintenance of the dam be undertaken on a regular basis and that records be kept of all major items of work performed.

It is also recommended that a detailed inspection of the dam be instituted on a regular basis by an engineer experienced in the design and construction of dams and that records be kept of all inspections made and remedial measures taken.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data are not available.

b. Experience Data. The drainage area and lake surface area were determined from the 1972 USGS Wright City, Missouri, Quadrangle Map. The proportions and dimensions of the spillway and dam were developed from surveys made during the inspection. Records of rainfall, streamflow, or flood data for the watershed were not available.

According to the St. Louis District, Corps of Engineers, the estimated flood damage zone, should failure of the dam occur, extends five miles downstream of the dam. A main line railroad track and an interstate highway lie within the flood damage zone. Both of these features may be hydrologically significant during occurrence of the probable maximum flood.

c. Visual Observations.

(1) The spillway, a shallow broad-crested irregular trapezoidal earth section, is located at the left (north) abutment.

(2) The original stream channel abuts the toe of the dam.

(3) Spillway releases within the capacity of the spillway outlet should not endanger the dam.

(4) Two small islands exist within the lake. These islands were disregarded in computing the storage capacity of the reservoir.

d. Overtopping Potential. The spillway is inadequate to pass the probable maximum flood, or 1/2 the probable maximum flood, without overtopping the dam. The results of the dam overtopping analyses are as follows:

(Note: The data appearing in the following table were extracted from the computer output data appearing in Appendix B. Decimal values have been rounded to the nearest one-tenth in order to prevent assumption of unwarranted accuracy.)

Ratio of PMF	Q-Peak Outflow (cfs)	Max Lake W.S. Elev.	Max. Depth (Ft.) of Flow over Dam (Elev. 807.1)	Duration of Overtopping of Dam (Hours)
0.50	1,294	807.8	0.7	1.2
1.00	3,825	808.9	1.8	4.2

Elevation 807.1 was found to be the lowest point in the dam crest. The flow safely passing the spillway just prior to overtopping was determined to be approximately 733 cfs, which is the routed outflow corresponding to about 33 percent of the probable maximum flood inflow. During peak flow of the probable maximum flood, the greatest depth of flow over the dam is projected to be 1.8 feet and overtopping will extend across the entire length of the dam.

e. Evaluation. Experience with embankments constructed of similar material (a silty lean clay of low plasticity) to that used to construct this dam has shown evidence that under certain conditions, such as high velocity flow, the material can be very erodible. An example of such erosion is evident in the downstream areas of the spillway outlet channel. Such a condition exists during the PMF when large lake outflow, accompanied by high flow velocities, occurs. For the PMF condition where the depth of flow over the dam crest, a maximum of 1.8 feet, and the duration of flow over the dam, 4.2 hours, are considerable, damage by erosion to the crest and downstream face of the dam is expected. The extent of these damages is not predictable; however, there is a possibility that they could result in failure by erosion of the dam.

f. References. Procedures and data for determining the probable maximum flood, the 1 percent chance (100-year frequency) flood, and the

discharge rating curve for flow passing the spillway and dam crest are presented on pages B-1 and B-2 of the Appendix. Listings of the HEC-1 (Dam Safety Version) input data for both the probable maximum flood and the 1 percent chance (100-year frequency) flood are shown on pages B-3 through B-5. Computer output data, including unit hydrograph ordinates, tabulation of PMF rainfall, loss and inflow data are shown on pages B-6 through B-9; tabulation of lake surface area, elevation and storage volume is shown on page B-10 and tabulations titled "Summary of Dam Safety Analysis" for the PMF and 1 percent chance (100-year frequency) flood are also shown on page B-10.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.1c.

b. Design and Construction Data. No design or construction data relating to the structural stability of the dam are known to exist. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Operating Records. No appurtenant structures or facilities requiring operation exist at this dam.

d. Post Construction Changes. Mr. David Bangert, a representative of the Owner, reported that the spillway was lowered approximately 18 inches and logs were placed along the upstream face of the dam in about 1968. Mr. Bangert also stated that to the knowledge of the present Owner, no other changes have been made or have occurred since 1968 that would affect the structural stability of the dam.

e. Seismic Stability. The dam is located in an area close to the boundary separating the Zone I and Zone II seismic probability areas. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading be applied in any stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. <u>Safety</u>. A hydraulic analysis indicated that the spillway is capable of passing lake outflow of about 733 cfs without the level of the lake exceeding the low point in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicated that for storm runoff of probable maximum flood magnitude, the lake outflow would be on the order of 3,825 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 277 cfs.

Seepage and stability analyses of the dam were not available for review, and therefore, no judgment could be made with respect to the structural stability of the dam.

Several items were noticed during the visual inspection that could adversely affect the safety of the dam. These items include trees and brush on the dam slopes, erosion of the upstream face of the dam, and seepage near the downstream toe.

b. <u>Adequacy of Information</u>. Due to lack of design and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection. The assessment of the hydrology of the watershed and the capacity of the spillway were based on a hydrologic/hydraulic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. <u>Urgency</u>. The items concerning the safety of the dam noted in paragraph 7.1a and the remedial measures recommended in paragraph 7.2 should be accomplished without undue delay.

d. <u>Necessity for Phase II</u>. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. The dam is located in an area close to the boundary separating the Zone I and Zone II seismic probability areas. An earthquake of the magnitude that might occur in this area would not be expected to cause structural damage to a well constructed earth dam of this size provided that static stability conditions are satisfactory and conventional safety margins exist. However, it is recommended that the prescribed seismic loading be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended:

(1) Based upon criteria set forth in the recommended guidelines, spillway size and/or height of dam should be increased to pass lake outflow resulting from a storm of probable maximum flood magnitude. In either case, the spillway should be protected to prevent erosion.

(2) Obtain the necessary soil data and perform dam seepage and stability analyses in order to determine the structural stability of the dam for all operational conditions. Seepage and stability analyses should be performed by a qualified professional engineer experienced in the design and construction of earthen dams.

b. Operations and Maintenance (O & M) Procedures. The following O & M Procedures are recommended:

(1) Remove the trees and brush from the dam proper and the areas adjacent to the downstream toe of slope. The removal of trees should be performed under the direction and guidance of an engineer experienced in the design and construction of earthen dams, since indiscriminate clearing can jeopardize the safety of the dam. Once the dam and adjacent downstream area are cleared of trees and brush, they should be thoroughly examined by an engineer for seepage, erosion, sloughing and other signs of instability. The existing turf cover should be restored if destroyed or missing. Maintain the turf cover at a height that will not hinder inspection of the embankment or

provide cover for burrowing animals. Holes from tree roots and voids created by burrowing animals can provide a pathway for seepage that could lead to a piping condition (progressive internal erosion) and potential failure of the dam.

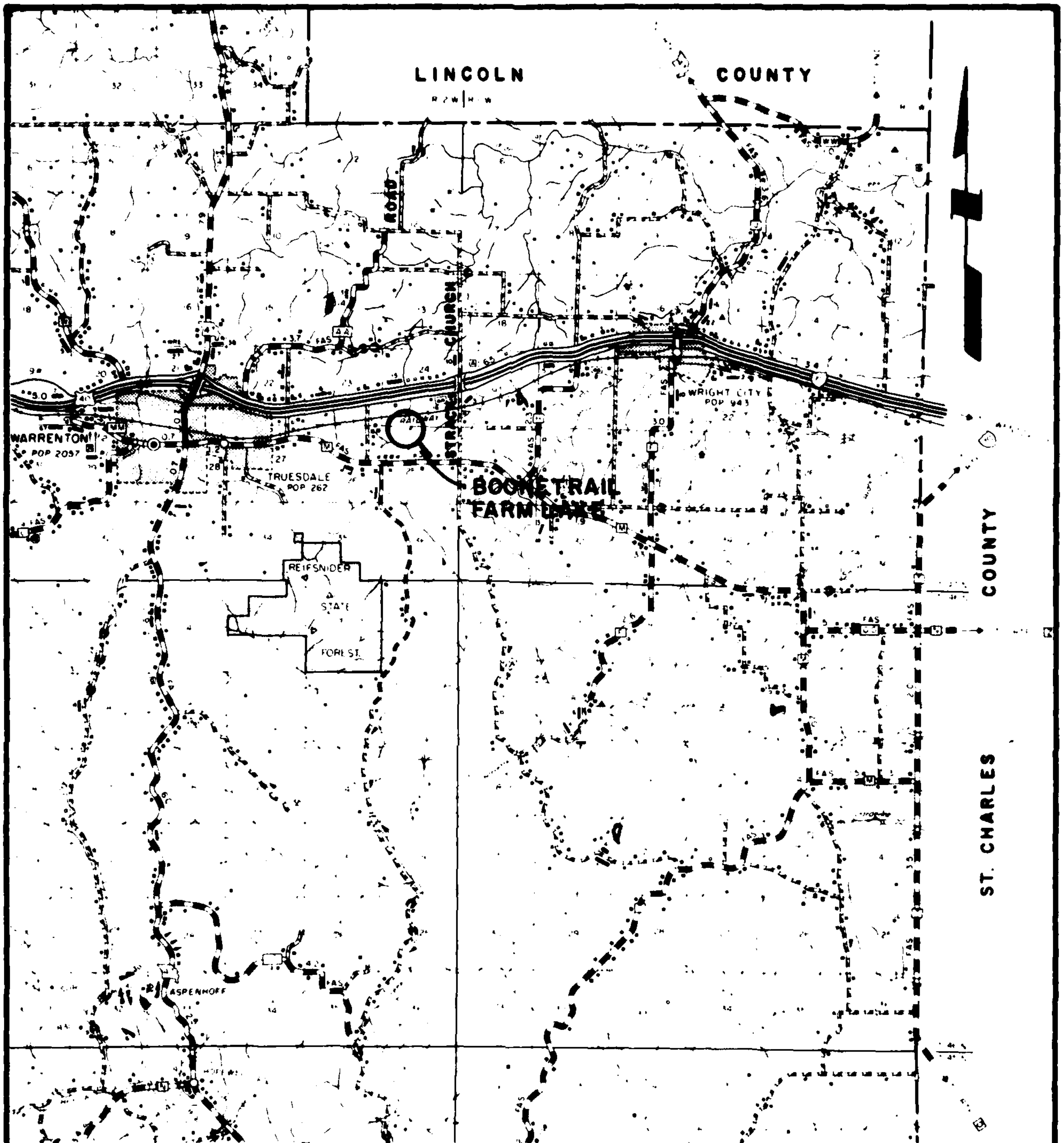
(2) Restore the upstream face of the dam and provide some form of protection other than grass (or logs) at and above the normal waterline in order to prevent erosion. A grass covered slope is not considered adequate protection to prevent erosion by wave action or by a fluctuating lake level.

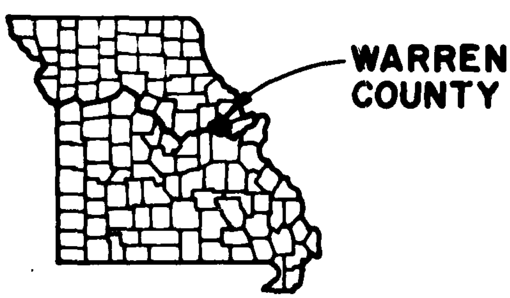
(3) Provide some means of controlling seepage evident in the area adjacent to the downstream toe to the left of the center of the dam. Uncontrolled seepage can lead to a piping condition which could result in failure of the dam. Drainage of the areas affected by seepage should be one of the objectives of the seepage control measures since saturation of the soil weakens the foundation which could impair the stability of the dam.

(4) Restore the dam crest to a uniform elevation and monitor the top of the dam through the area of suspected settlement in order to determine the extent of possible future settlement and the remedial work required to compensate for such settlement. The crest of the dam should be uniform throughout without low areas that reduce dam freeboard and penalize spillway capacity.

(5) Provide maintenance of all areas of the dam and spillway on a regularly scheduled basis in order to insure these features of being in satisfactory operational condition.

(6) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended that records be kept for future reference of all inspections made and remedial measures taken.

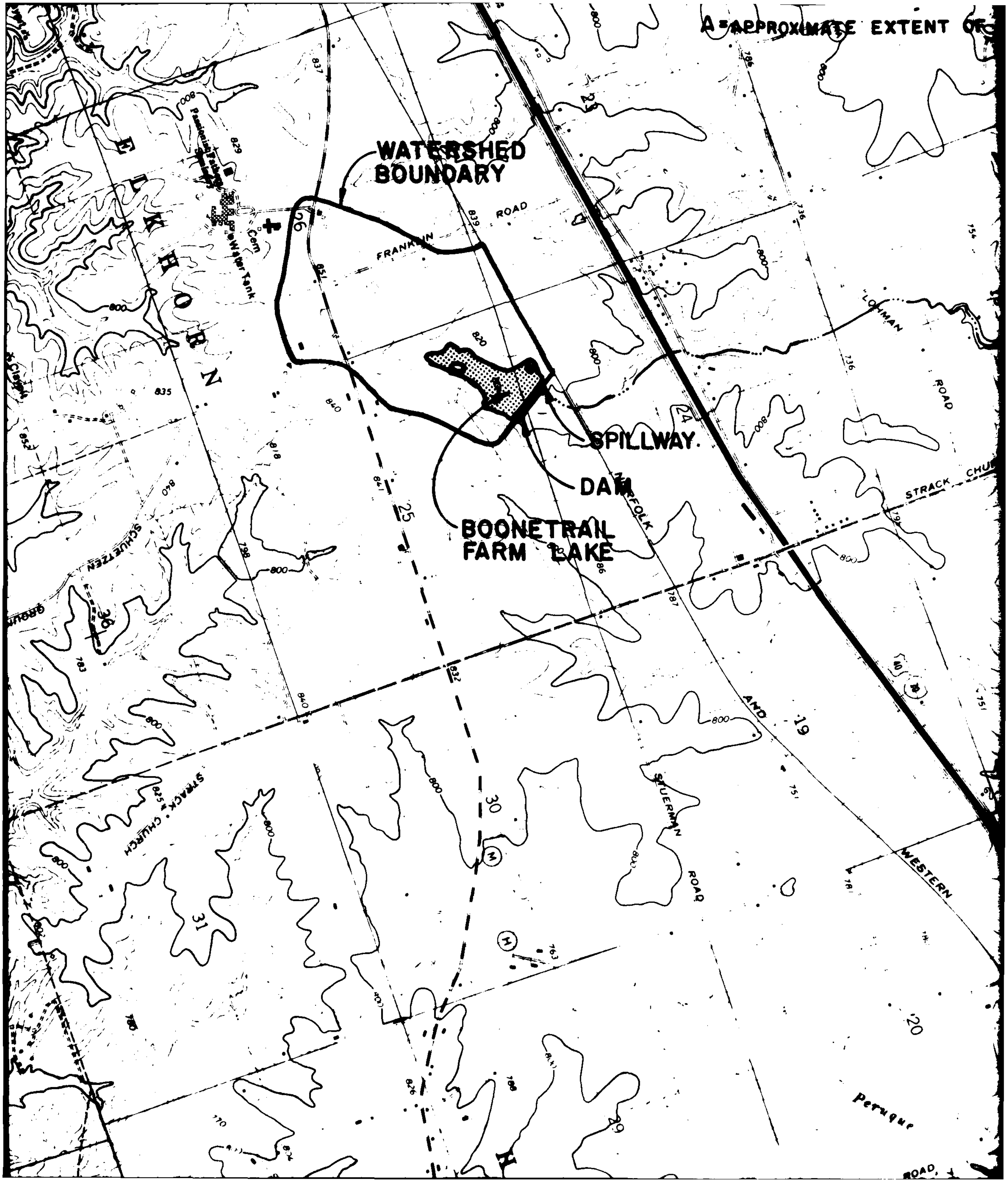


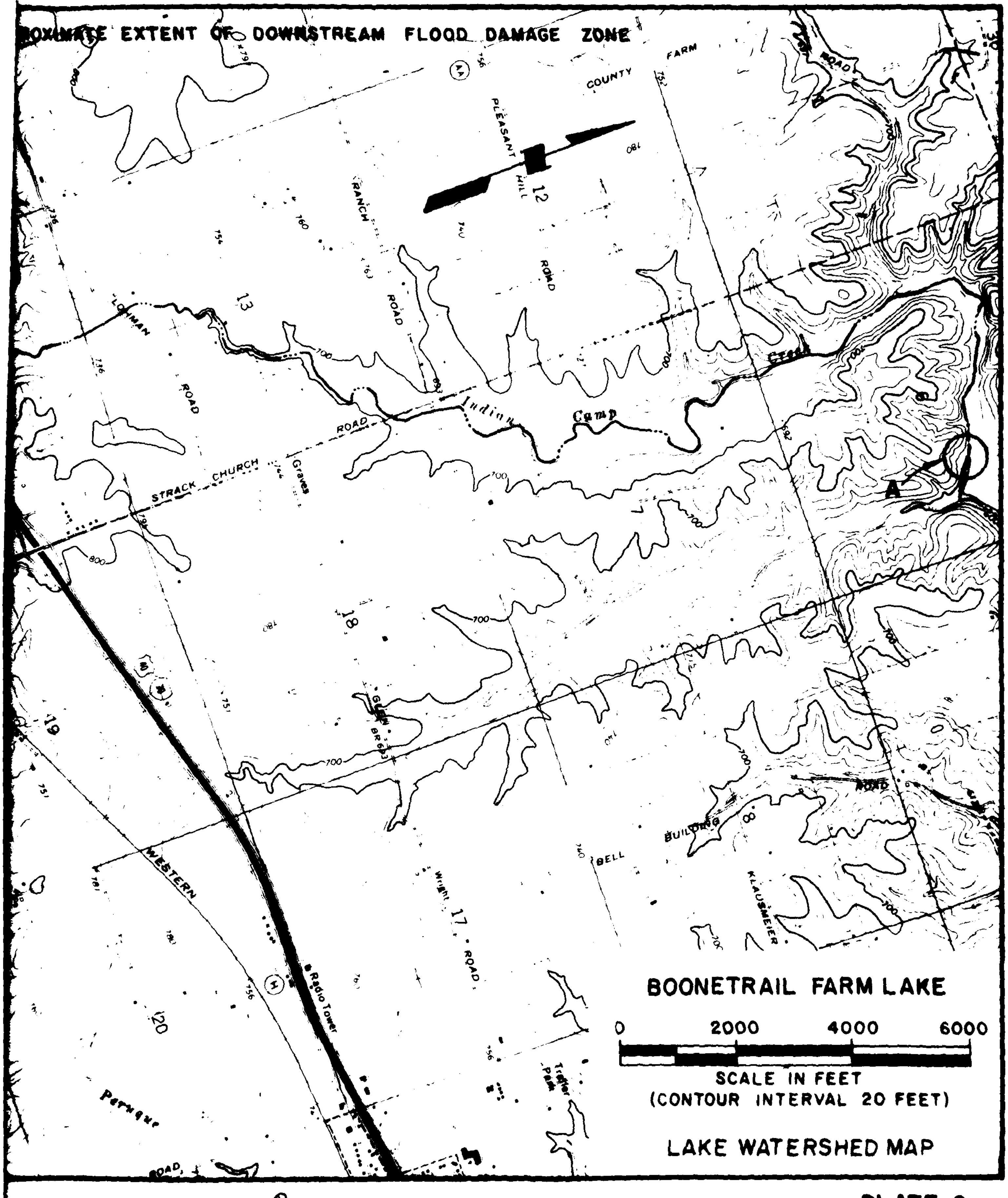


LOCATION MAP

BOONETRAIL FARM LAKE

REGIONAL VICINITY MAP


A=APPROXIMATE EXTENT OF
WATERSHED BOUNDARY
SPILLWAY
DAM
BOONETRAIL FARM LAKE
FRANKLIN ROAD
NORFOLK AND WESTERN
STRACK CHURCH
SCHUETZEN
STUERMAN ROAD
LOHMAN ROAD
Peruque ROAD



BOONETRAIL FARM LAKE

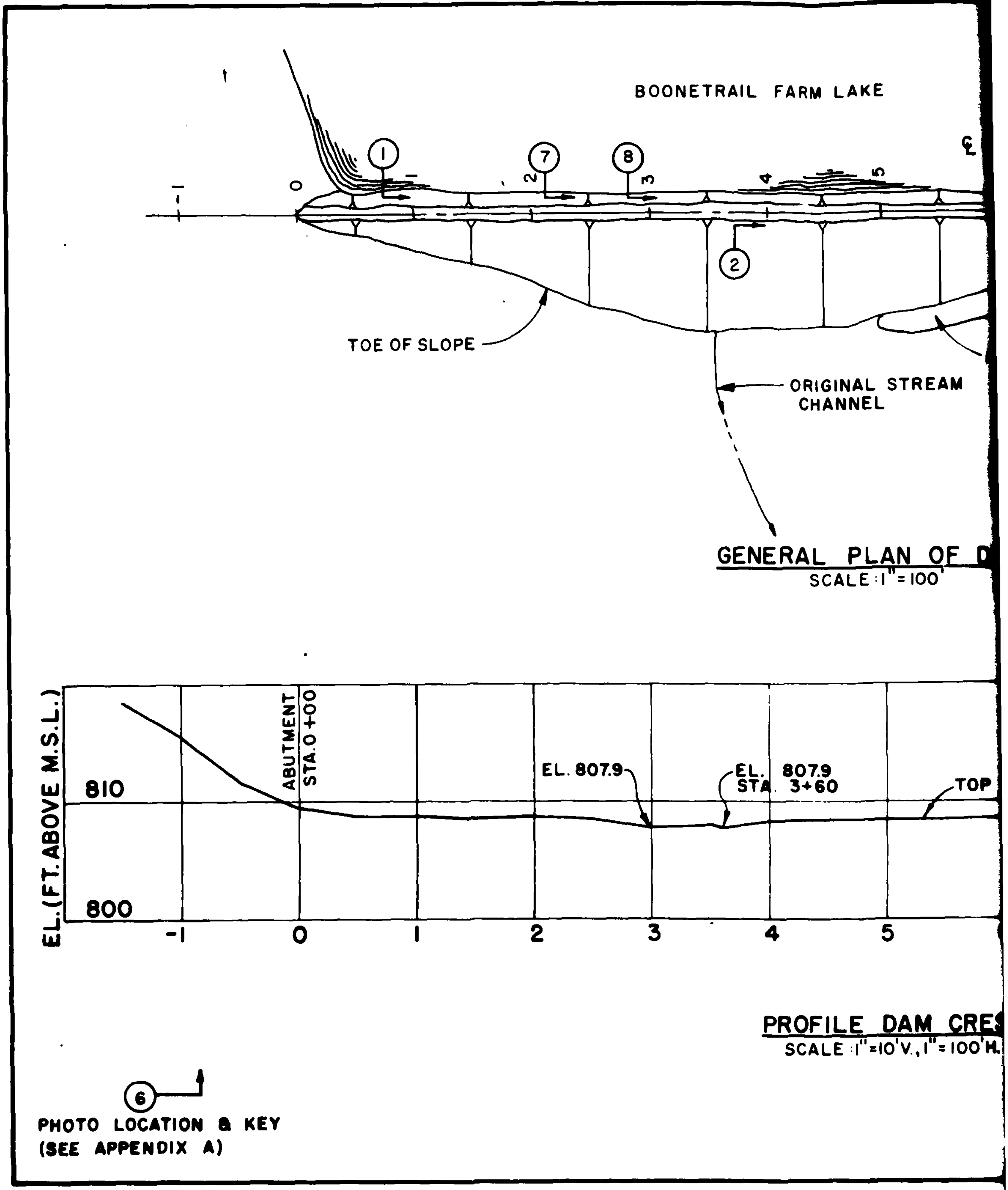
0 2000 4000 6000

SCALE IN FEET

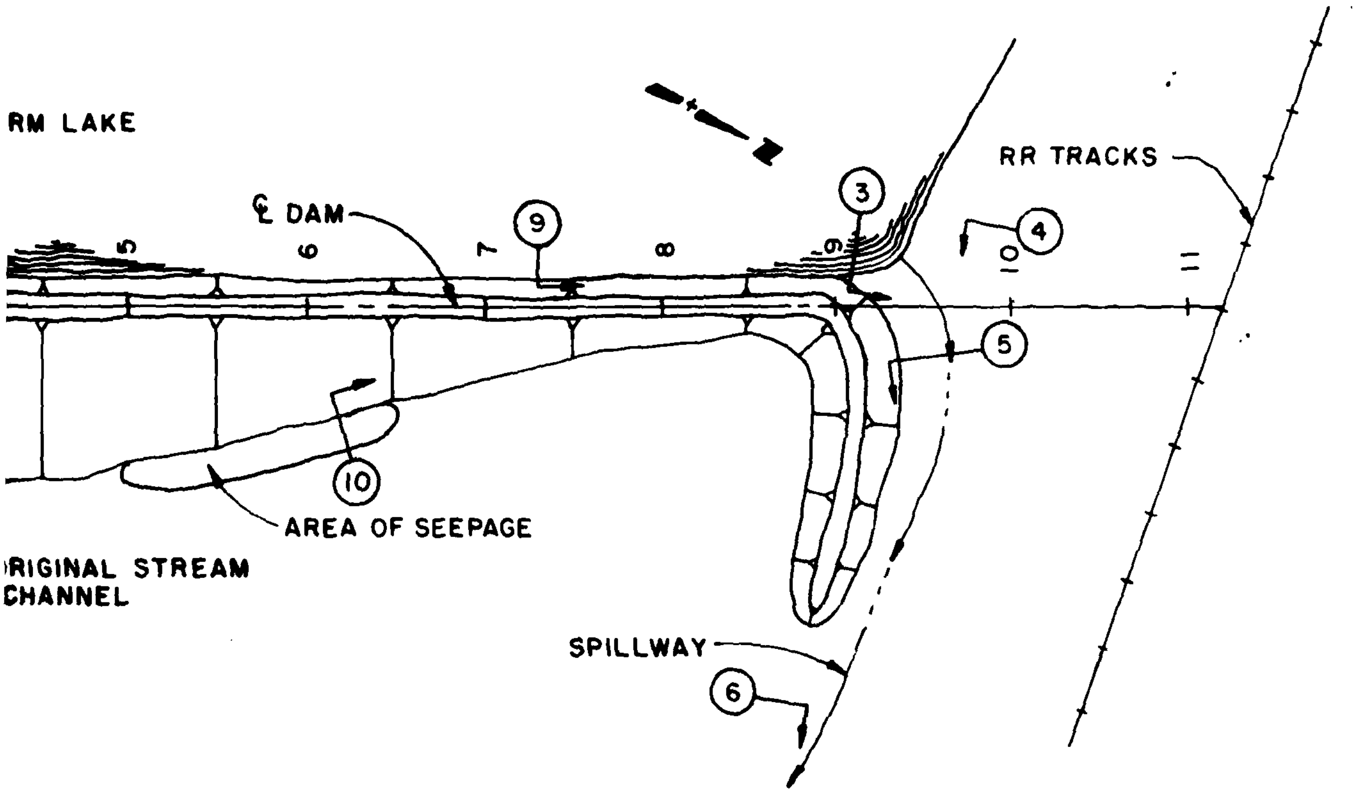
(CONTOUR INTERVAL 20 FEET)

LAKE WATERSHED MAP

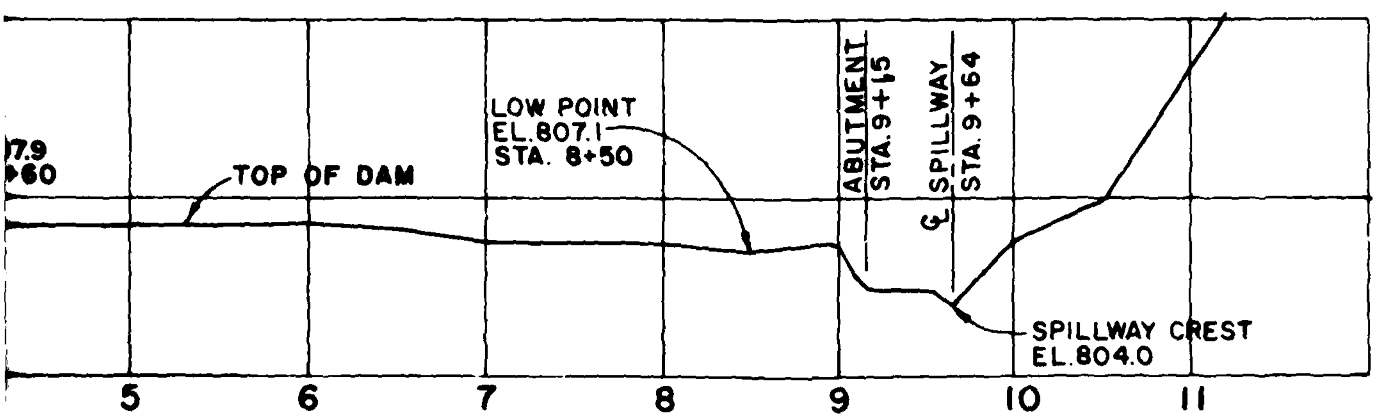
PLATE 2



BOONETRAIL FARM LAKE
TOE OF SLOPE
ORIGINAL STREAM CHANNEL
GENERAL PLAN OF D
SCALE: 1" = 100'
EL. (FT. ABOVE M.S.L.)
810
800
ABUTMENT STA. 0+00
EL. 807.9
EL. 807.9 STA. 3+60
TOP
-1
0
1
2
3
4
5
PROFILE DAM CRES
SCALE: 1" = 10' V., 1" = 100' H.
PHOTO LOCATION & KEY
(SEE APPENDIX A)



AL PLAN OF DAM
SCALE: 1" = 100'



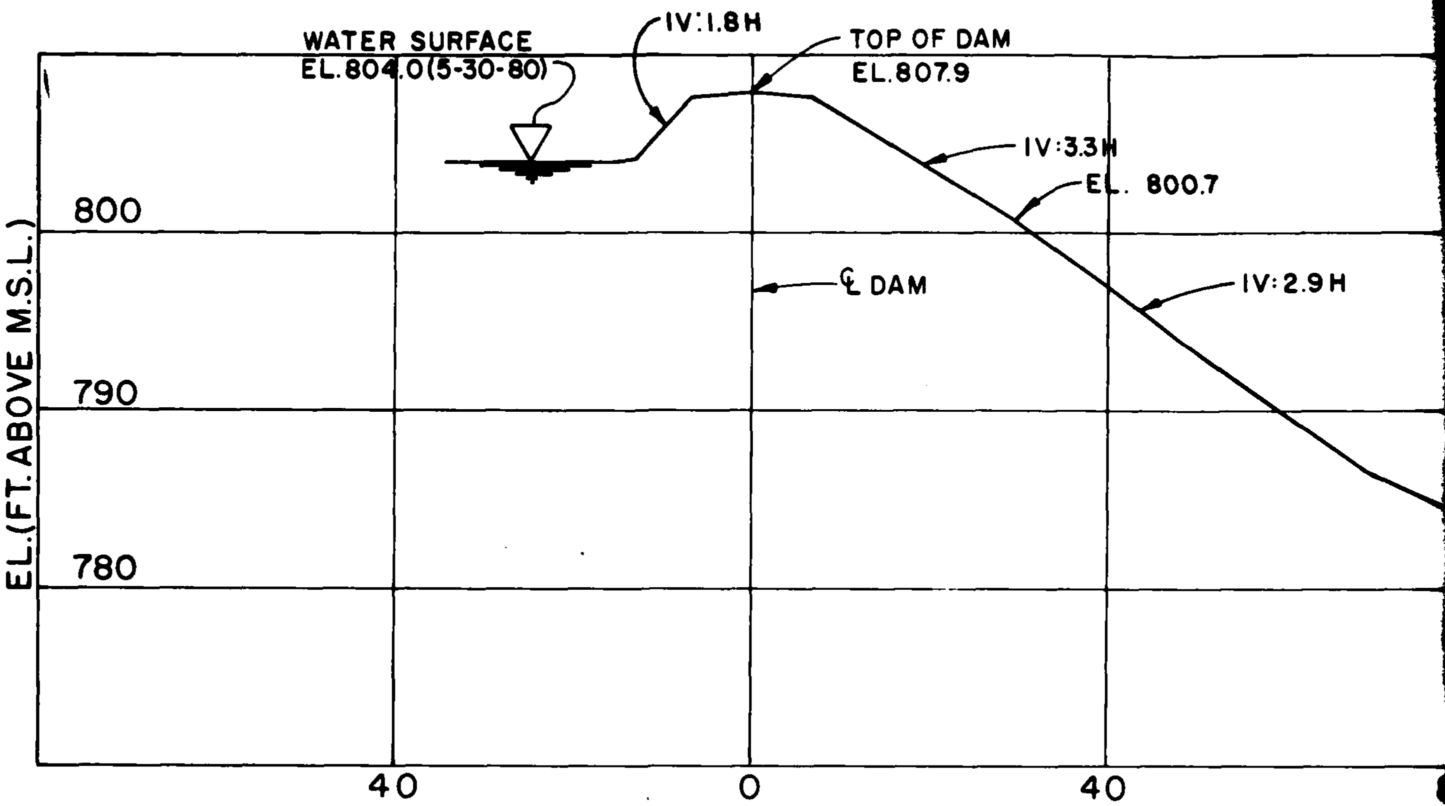
FILE DAM CREST
ALE: 1" = 10' V., 1" = 100' H.

BOONETRAIL FARM LAKE
DAM PLAN & PROFILE

Horner & Shifrin, Inc. July 1980

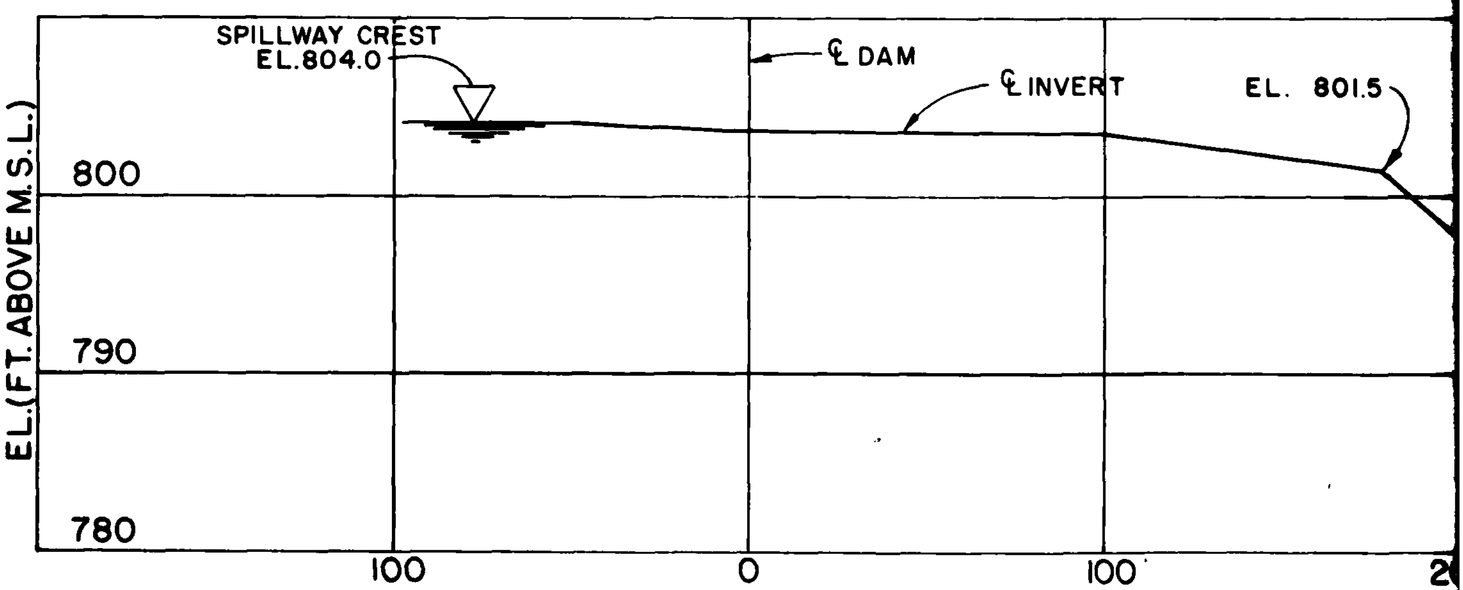
2

PLATE 3



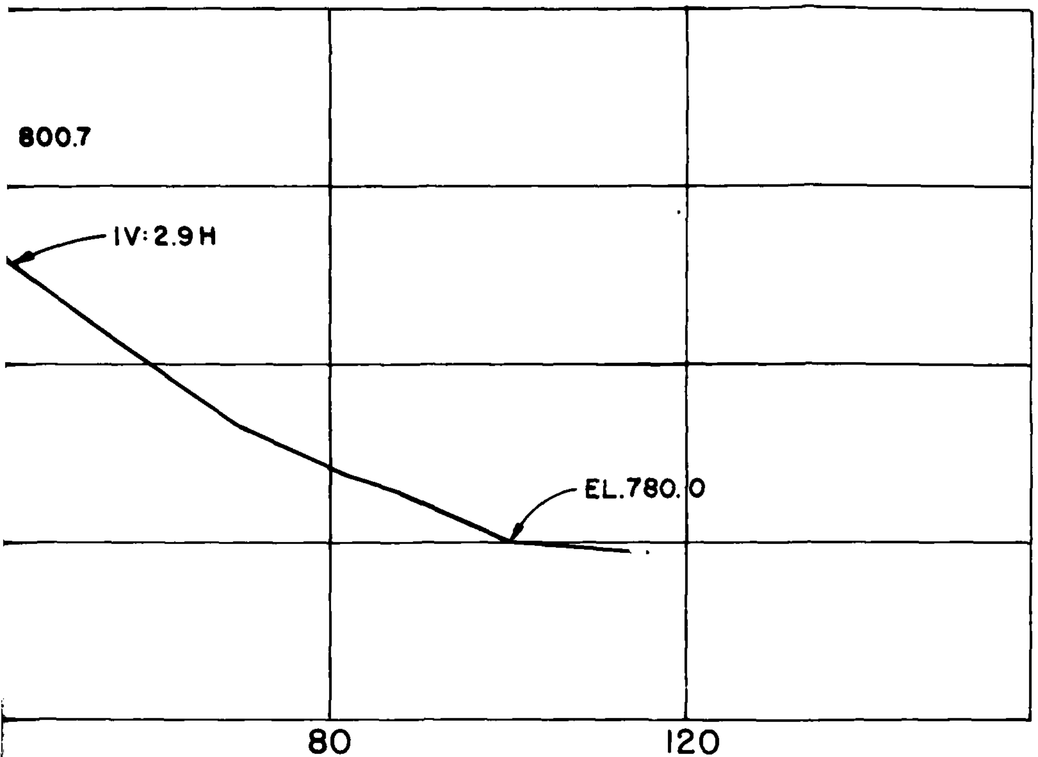
DAM CROSS-SECTION STA.3+60

SCALE: 1"=10'V., 1"=20'H.

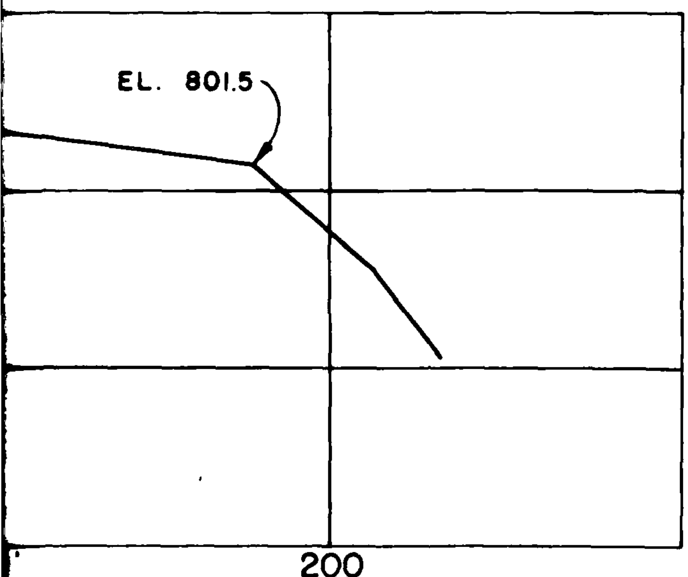


PROFILE SPILLWAY ℄

SCALE: 1"=10'V., 1"=50'H.



N STA.3+60
=20'H.

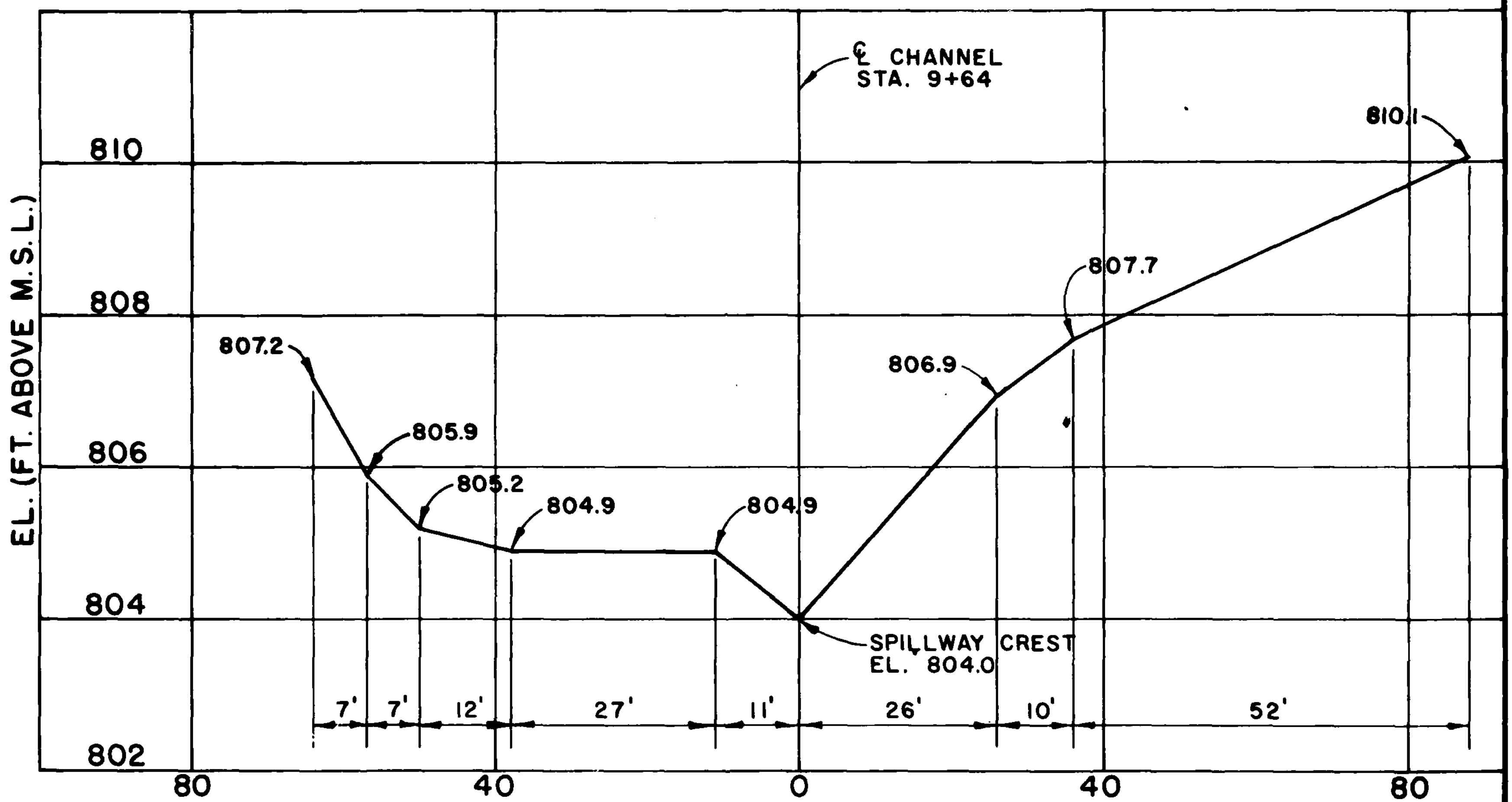


BOONETRAIL FARM LAKE
DAM CROSS-SECTION &
SPILLWAY PROFILE

Horner & Shifrin, Inc. July 1980

1 2

PLATE 4



CROSS-SECTION SPILLWAY CHANNEL ℄ DAM

SCALE: 1" = 2' V., 1" = 20' H.

BOONETRAIL FARM LAKE
CROSS-SECTION
SPILLWAY CHANNEL

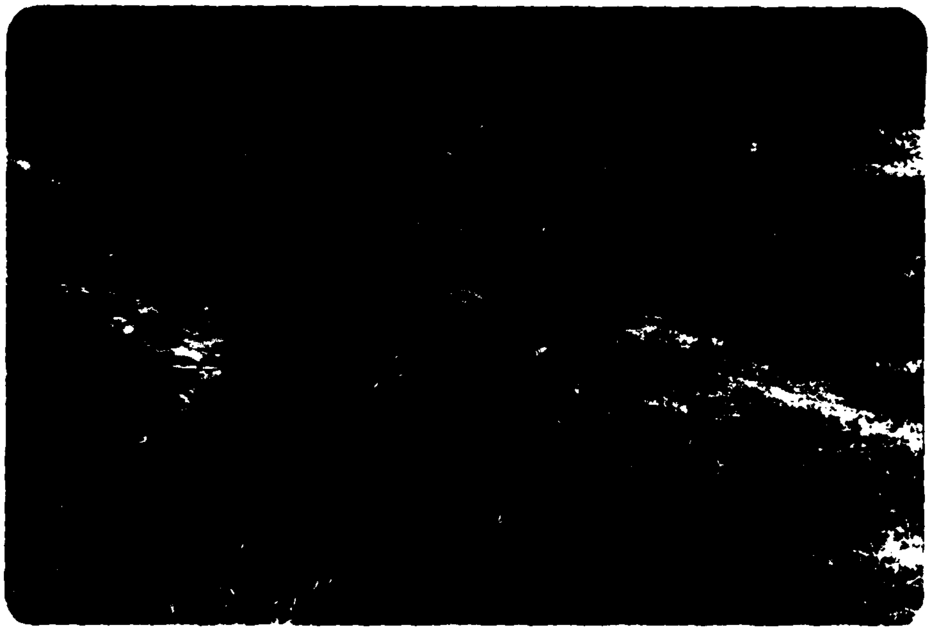
Horner & Shifrin, Inc. Sept. 1980

APPENDIX A

INSPECTION PHOTOGRAPHS

NO. 1: UPSTREAM FACE OF DAM

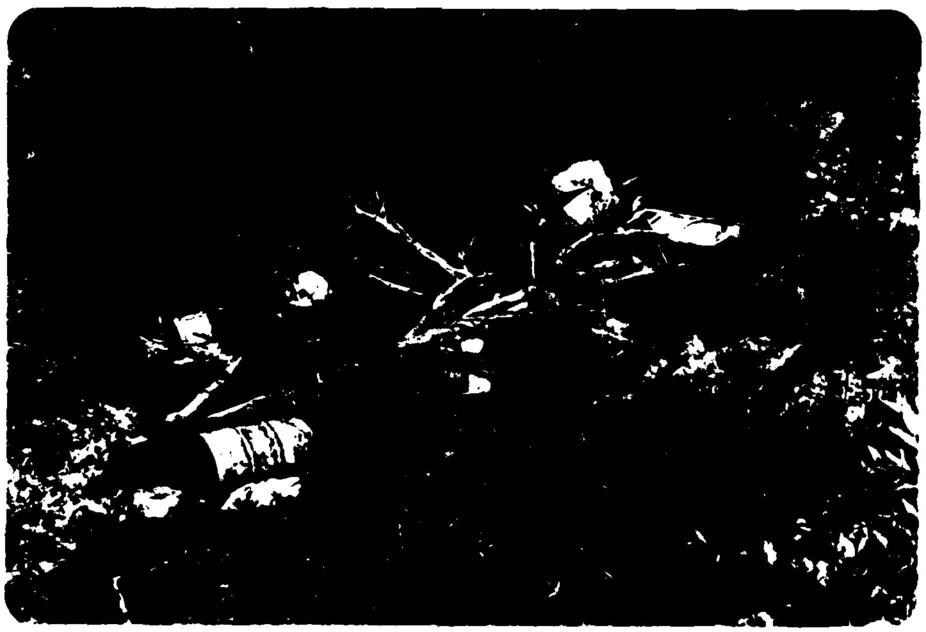
NO. 2: DOWNSTREAM FACE OF DAM



NO. 3: SPILLWAY CREST

NO. 4: SPILLWAY OUTLET CHANNEL

NO. 5: EROSION PROTECTION IN SPILLWAY OUTLET CHANNEL



NO. 6: DEBRIS IN SPILLWAY OUTLET CHANNEL

NO. 7: RUBBLE SLOPE PROTECTION AT UPSTREAM FACE

NO. 8: LOG SLOPE PROTECTION AT UPSTREAM FACE

NO. 9: EROSION OF UPSTREAM FACE

NO. 10: SEEPAGE NEAR TOE OF DAM

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hour value equals 25.0 inches) from Hydrometeorological Report No. 33. The precipitation data used in the analysis of the 1 percent (100-year flood) was provided by the St. Louis District, Corps of Engineers. Due to the fact that the watershed for this reservoir is small, the lake level was assumed to be at normal pool as a result of antecedent storms prior to occurrence of the PMF and the probabilistic storm.

b. Drainage area = 0.433 square miles = 277 acres.

c. SCS parameters:

Time of Concentration (Tc) = $\left(\frac{11.9L^3}{H}\right)^{0.385}$ = 0.340 hours

Where: T_c = Travel time of water from hydraulically most distant point of interest, hours.*

L = Length of longest watercourse = 0.663 miles.

H = Elevation difference = 57 feet.

Lag time = 0.204 hours (0.60 Tc)

Hydrologic Soil Group = 5% C (Dockery Series) & 95% D (Keswick Series) per SCS County Soil Report

*The time of concentration (Tc) ws obtained using Method C as described in Figure 30, "Design of Small Dams" by the United States Department of the Interior, Bureau of Reclamation, and was verified using average channel velocity estimates and watercourse lengths.

Soil type CN = 80 (AMC II, 100-yr flood condition)
= 91 (AMC III, PMF condition)

2. The spillway section consists of a broad-crested, irregular trapezoidal section for which conventional weir formulas do not apply.

Spillway release rates were determined as follows:

a. Spillway crest section properties (areas, "a", and top width, "t") were computed for various depths, "d".

b. It was assumed that flow over the spillway crest would occur at critical depth. Flow at critical depth was computed as

$Qc = (\frac{a^3 g}{t})^{0.5}$ for the various depths, "d". Corresponding velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.* Reference, "Handbook of Hydraulics", Fifth Edition, by King & Brater, page 8-7.

c. Static lake levels corresponding to the various flow values passing the spillway were computed as critical depths plus critical velocity heads ($d_c + H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

4. The profile of the dam crest is irregular and flow over the dam cannot be determined by application of conventional weir formulas. Crest length and elevation data for the dam crest proper were entered into the HEC-1 Program on the $L and the $V cards. The program assumes that flow over the dam crest section occurs at critical depth and computes internally the flow over the dam crest and adds this flow to the flow passing the spillway as entered on the Y4 and Y5 cards.

* $v_c = \frac{Qc}{a}$; $Hvc = \frac{{v_c}^2}{2g}$

```
A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF BOONETRAIL FARM LAKE DAM
A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
B     288       0       5       0       0       0       0       0       0       0
B1      5
J       1       4       1
J1   0.33    0.34    0.50    1.00
K       0  INFLOW                                   1
K1       INFLOW HYDROGRAPH
M       1       2   0.433                   1.0                     1
P       0    25.0     102     120     130
T                                                  -1     -91
W2          0.204
X    -1.0    -.10     2.0
K       1     DAM                                   1
K1       RESERVOIR ROUTING BY MODIFIED PULS
Y                               1       1
Y1      1                                      205.60       1
Y4  804.0   805.1   805.4   806.0   806.4   807.1   807.3   [illegible]   808.8   809.2
Y4  809.8   810.5   811.2   811.8
Y5      0      33   [illegible]     246     401     733    1142    1419    1764    2302
Y5   2737    3670    4679    5735
$A      0    15.7    29.0    68.0   105.0
$E    780     804     810     820     830
$$  804.0
$D  807.1
$L      0     100     200     220     307     391     856     900     950    1000
$V  807.1   807.[illegible]   807.7   807.9   808.0   808.3   808.[illegible]   809.4   811.7   815.4
K      99
```

```
1A1      ANALYSIS OF DAM OVERTOPPING USING 100-YR FLOOD
A2      HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF BOONETRAIL FARM LAKE DAM
A3      100-YR FLOOD ROUTED THROUGH RESERVOIR
B     288      0      5                                      4
B1      5
J       1      1      1
J1   1.00
K       0   INFLOW                               1
K1      INFLOW HYDROGRAPH
M       0      2  0.433               1.0                    1
O     288  7.094
O1   .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
O1   .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
O1   .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
O1   .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
O1   .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
O1   .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
O1   .006   .006   .006   .006   .006   .006   .006   .006   .006   .006
O1   .006   .006   .014   .014   .014   .014   .014   .014   .014   .014
O1   .014   .014   .014   .014   .014   .014   .014   .014   .014   .014
O1   .014   .014   .014   .014   .014   .014   .014   .014   .014   .014
O1   .014   .014   .014   .014   .014   .014   .014   .014   .024   .024
O1   .024   .024   .024   .024   .024   .024   .024   .024   .024   .024
O1   .024   .024   .024   .024   .024   .024   .029   .029   .029   .029
O1   .029   .029   .060   .060   .060   .060   .060   .060   .129   .129
O1   [illegible]   .247   .247   .546   [illegible]   .380   .247   .130   .130   .129
O1   [illegible]   .060   .060   .060   .060   [illegible]   .029   .029   .029   .029
O1   .029   .029   .024   .024   .024   .024   .024   .024   .024   .024
O1   .024   .024   .024   .024   .024   .024   .024   .024   .024   .024
```

100-YR. FLOOD (Cont'd)

01	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
01	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
01	.014	.014	.014	.014	.014	.014	.014	.014	.014	.014
01	.014	.014	.014	.014	.014	.014	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006	.006	.006
01	.006	.006	.006	.006	.006	.006	.006	.006		
T							-1	-80		
W2		0.204								
X	-1.0	-.10	2.0							
K	1	DAM					1			
K1	RESERVOIR ROUTING BY MODIFIED PULS									
Y				1	1					
Y1	1						205.60	-1		
Y4	804.0	805.1	805.4	806.0	806.4	807.1	807.0	808.2	808.8	809.2
Y4	807.8	810.5	811.2	811.8						
Y5	0	33	89	246	401	733	1142	1419	1964	2302
Y5	2909	3670	4679	5635						
$A	0	25.7	39.0	68.0	105.0					
$E	730	804	810	820	830					
$$	804.0									
$D	807.1									
$L	0	100	200	220	307	[illegible]	856	900	950	1000
$V	807.1	807.6	807.7	807.9	808.6	808.9	[illegible]	809.6	811.7	811.4
K	99									

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF BOONETRAIL FARM LAKE DAM
RATIOS OF PMF ROUTED THROUGH RESERVOIR

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= .33 .34 .50 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INFLOW	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.43	0.00	.43	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	25.00	102.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-91.00	0.00	0.00

CURVE NO = -91.00 WETNESS = -1.00 EFFECT CN = 91.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .20

RECESSION DATA
STRTQ= -1.00 QRCSN= -.10 RTIOR= 2.00

UNIT HYDROGRAPH 14 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .20 VOL= 1.00

202.	670.	852.	695.	396.	228.	132.	77.	44.	25.
15.	9.	5.	2.						

END-OF-PERIOD FLOW

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	0.00	.01	0.	1.01	12.05	145	.21	.21	.01	234.
1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.21	.21	.00	332.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.21	.21	.00	457.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.21	.21	.00	559.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.21	.21	.00	618.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.21	.21	.00	652.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.21	.21	.00	672.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.21	.21	.00	684.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.21	.21	.00	692.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.21	.21	.00	696.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.21	.21	.00	699.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.21	.21	.00	700.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.26	.25	.00	710.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.26	.25	.00	739.
1.01	1.15	15	.01	.00	.01	0.	1.01	13.15	159	.26	.25	.00	776.
1.01	1.20	16	.01	.00	.01	0.	1.01	13.20	160	.26	.25	.00	805.
1.01	1.25	17	.01	.00	.01	1.	1.01	13.25	161	.26	.25	.00	822.
1.01	1.30	18	.01	.00	.01	1.	1.01	13.30	162	.26	.25	.00	832.
1.01	1.35	19	.01	.00	.01	2.	1.01	13.35	163	.26	.25	.00	838.
1.01	1.40	20	.01	.00	.01	3.	1.01	13.40	164	.26	.25	.00	842.
1.01	1.45	21	.01	.00	.01	4.	1.01	13.45	165	.26	.25	.00	844.
1.01	1.50	22	.01	.00	.01	5.	1.01	13.50	166	.26	.25	.00	846.
1.01	1.55	23	.01	.00	.01	6.	1.01	13.55	167	.26	.25	.00	847.
1.01	2.00	24	.01	.00	.01	7.	1.01	14.00	168	.26	.25	.00	847.
1.01	2.05	25	.01	.00	.01	8.	1.01	14.05	169	.32	.32	.00	861.
1.01	2.10	26	.01	.00	.01	9.	1.01	14.10	170	.32	.32	.00	904.
1.01	2.15	27	.01	.00	.01	10.	1.01	14.15	171	.32	.32	.00	958.
1.01	2.20	28	.01	.00	.01	11.	1.01	14.20	172	.32	.32	.00	1002.
1.01	2.25	29	.01	.00	.01	12.	1.01	14.25	173	.32	.32	.00	1028.
1.01	2.30	30	.01	.00	.01	13.	1.01	14.30	174	.32	.32	.00	1042.
1.01	2.35	31	.01	.00	.01	14.	1.01	14.35	175	.32	.32	.00	1051.
1.01	2.40	32	.01	.00	.01	14.	1.01	14.40	176	.32	.32	.00	1056.
1.01	2.45	33	.01	.01	.01	15.	1.01	14.45	177	.32	.32	.00	1059.
1.01	2.50	34	.01	.01	.01	16.	1.01	14.50	178	.32	.32	.00	1061.
1.01	2.55	35	.01	.01	.01	17.	1.01	14.55	179	.32	.32	.00	1062.
1.01	3.00	36	.01	.01	.01	17.	1.01	15.00	180	.32	.32	.00	1063.
1.01	3.05	37	.01	.01	.01	18.	1.01	15.05	181	.19	.19	.00	1038.
1.01	3.10	38	.01	.01	.01	18.	1.01	15.10	182	.39	.39	.00	994.
1.01	3.15	39	.01	.01	.01	19.	1.01	15.15	183	.39	.39	.00	1018.
1.01	3.20	40	.01	.01	.01	20.	1.01	15.20	184	.58	.58	.00	1135.
1.01	3.25	41	.01	.01	.01	20.	1.01	15.25	185	.68	.68	.00	1369.
1.01	3.30	42	.01	.01	.01	21.	1.01	15.30	186	1.65	1.64	.00	1842.
1.01	3.35	43	.01	.01	.01	21.	1.01	15.35	187	2.71	2.71	.01	2950.
1.01	3.40	44	.01	.01	.01	22.	1.01	15.40	188	1.07	1.06	.00	4314.
1.01	3.45	45	.01	.01	.01	22.	1.01	15.45	189	.68	.68	.00	4805.
1.01	3.50	46	.01	.01	.01	23.	1.01	15.50	190	.58	.58	.00	4301.
1.01	3.55	47	.01	.01	.01	23.	1.01	15.55	191	.39	.39	.00	3398.
1.01	4.00	48	.01	.01	.01	24.	1.01	16.00	192	.39	.39	.00	2654.
1.01	4.05	49	.01	.01	.01	24.	1.01	16.05	193	.30	.30	.00	2101.

END-OF-PERIOD FLOW (Cont'd)

1.01	4.10	50	.01	.01	.01	25.
1.01	4.15	51	.01	.01	.01	25.
1.01	4.20	52	.01	.01	.01	25.
1.01	4.25	53	.01	.01	.01	26.
1.01	4.30	54	.01	.01	.01	26.
1.01	4.35	55	.01	.01	.01	27.
1.01	4.40	56	.01	.01	.01	27.
1.01	4.45	57	.01	.01	.01	27.
1.01	4.50	58	.01	.01	.01	28.
1.01	4.55	59	.01	.01	.01	28.
1.01	5.00	60	.01	.01	.01	28.
1.01	5.05	61	.01	.01	.01	29.
1.01	5.10	62	.01	.01	.01	29.
1.01	5.15	63	.01	.01	.00	29.
1.01	5.20	64	.01	.01	.00	29.
1.01	5.25	65	.01	.01	.00	30.
1.01	5.30	66	.01	.01	.00	30.
1.01	5.35	67	.01	.01	.00	30.
1.01	5.40	68	.01	.01	.00	31.
1.01	5.45	69	.01	.01	.00	31.
1.01	5.50	70	.01	.01	.00	31.
1.01	5.55	71	.01	.01	.00	31.
1.01	6.00	72	.01	.01	.00	32.
1.01	6.05	73	.06	.04	.02	39.
1.01	6.10	74	.06	.05	.02	62.
1.01	6.15	75	.06	.05	.02	93.
1.01	6.20	76	.06	.05	.02	119.
1.01	6.25	77	.06	.05	.01	135.
1.01	6.30	78	.06	.05	.01	146.
1.01	6.35	79	.06	.05	.01	153.
1.01	6.40	80	.06	.05	.01	159.
1.01	6.45	81	.06	.05	.01	163.
1.01	6.50	82	.06	.05	.01	166.
1.01	6.55	83	.06	.05	.01	169.
1.01	7.00	84	.06	.05	.01	171.
1.01	7.05	85	.06	.05	.01	173.
1.01	7.10	86	.06	.05	.01	175.
1.01	7.15	87	.06	.05	.01	177.
1.01	7.20	88	.06	.05	.01	179.
1.01	7.25	89	.06	.05	.01	180.
1.01	7.30	90	.06	.06	.01	181.
1.01	7.35	91	.06	.06	.01	183.
1.01	7.40	92	.06	.06	.01	184.
1.01	7.45	93	.06	.06	.01	185.
1.01	7.50	94	.06	.06	.01	186.
1.01	7.55	95	.06	.06	.01	187.
1.01	8.00	96	.06	.06	.01	188.
1.01	8.05	97	.06	.06	.01	189.
1.01	8.10	98	.06	.06	.01	189.
1.01	8.15	99	.06	.06	.01	190.
1.01	8.20	100	.06	.06	.00	191.
1.01	8.25	101	.06	.06	.00	192.
1.01	16.10	194	.30	.30	.00	1693.
1.01	16.15	195	.30	.30	.00	1415.
1.01	16.20	196	.30	.30	.00	1237.
1.01	16.25	197	.30	.30	.00	1135.
1.01	16.30	198	.30	.30	.00	1076.
1.01	16.35	199	.30	.30	.00	1041.
1.01	16.40	200	.30	.30	.00	1018.
1.01	16.45	201	.30	.30	.00	1005.
1.01	16.50	202	.30	.30	.00	1000.
1.01	16.55	203	.30	.30	.00	998.
1.01	17.00	204	.30	.30	.00	996.
1.01	17.05	205	.23	.23	.00	983.
1.01	17.10	206	.23	.23	.00	940.
1.01	17.15	207	.23	.23	.00	886.
1.01	17.20	208	.23	.23	.00	842.
1.01	17.25	209	.23	.23	.00	817.
1.01	17.30	210	.23	.23	.00	802.
1.01	17.35	211	.23	.23	.00	794.
1.01	17.40	212	.23	.23	.00	789.
1.01	17.45	213	.23	.23	.00	786.
1.01	17.50	214	.23	.23	.00	785.
1.01	17.55	215	.23	.23	.00	784.
1.01	18.00	216	.23	.23	.00	783.
1.01	18.05	217	.02	.02	.00	740.
1.01	18.10	218	.02	.02	.00	597.
1.01	18.15	219	.02	.02	.00	469.
1.01	18.20	220	.02	.02	.00	438.
1.01	18.25	221	.02	.02	.00	408.
1.01	18.30	222	.02	.02	.00	381.
1.01	18.35	223	.02	.02	.00	355.
1.01	18.40	224	.02	.02	.00	332.
1.01	18.45	225	.02	.02	.00	309.
1.01	18.50	226	.02	.02	.00	289.
1.01	18.55	227	.02	.02	.00	269.
1.01	19.00	228	.02	.02	.00	251.
1.01	19.05	229	.02	.02	.00	234.
1.01	19.10	230	.02	.02	.00	219.
1.01	19.15	231	.02	.02	.00	204.
1.01	19.20	232	.02	.02	.00	190.
1.01	19.25	233	.02	.02	.00	178.
1.01	19.30	234	.02	.02	.00	166.
1.01	19.35	235	.02	.02	.00	155.
1.01	19.40	236	.02	.02	.00	144.
1.01	19.45	237	.02	.02	.00	135.
1.01	19.50	238	.02	.02	.00	126.
1.01	19.55	239	.02	.02	.00	117.
1.01	20.00	240	.02	.02	.00	109.
1.01	20.05	241	.02	.02	.00	102.
1.01	20.10	242	.02	.02	.00	95.
1.01	20.15	243	.02	.02	.00	89.
1.01	20.20	244	.02	.02	.00	83.
1.01	20.25	245	.02	.02	.00	77.

END-OF-PERIOD FLOW (Cont'd)

1.01	8.30	102	.06	.06	.00	192.
1.01	8.35	103	.06	.06	.00	193.
1.01	8.40	104	.06	.06	.00	193.
1.01	8.45	105	.06	.06	.00	194.
1.01	8.50	106	.06	.06	.00	195.
1.01	8.55	107	.06	.06	.00	195.
1.01	9.00	108	.06	.06	.00	195.
1.01	9.05	109	.06	.06	.00	196.
1.01	9.10	110	.06	.06	.00	196.
1.01	9.15	111	.06	.06	.00	197.
1.01	9.20	112	.06	.06	.00	197.
1.01	9.25	113	.06	.06	.00	198.
1.01	9.30	114	.06	.06	.00	198.
1.01	9.35	115	.06	.06	.00	198.
1.01	9.40	116	.06	.06	.00	199.
1.01	9.45	117	.06	.06	.00	199.
1.01	9.50	118	.06	.06	.00	199.
1.01	9.55	119	.06	.06	.00	199.
1.01	10.00	120	.06	.06	.00	200.
1.01	10.05	121	.06	.06	.00	200.
1.01	10.10	122	.06	.06	.00	200.
1.01	10.15	123	.06	.06	.00	200.
1.01	10.20	124	.06	.06	.00	201.
1.01	10.25	125	.06	.06	.00	201.
1.01	10.30	126	.06	.06	.00	201.
1.01	10.35	127	.06	.06	.00	201.
1.01	10.40	128	.06	.06	.00	202.
1.01	10.45	129	.06	.06	.00	202.
1.01	10.50	130	.06	.06	.00	202.
1.01	10.55	131	.06	.06	.00	202.
1.01	11.00	132	.06	.06	.00	202.
1.01	11.05	133	.06	.06	.00	202.
1.01	11.10	134	.06	.06	.00	203.
1.01	11.15	135	.06	.06	.00	203.
1.01	11.20	136	.06	.06	.00	203.
1.01	11.25	137	.06	.06	.00	203.
1.01	11.30	138	.06	.06	.00	203.
1.01	11.35	139	.06	.06	.00	203.
1.01	11.40	140	.06	.06	.00	203.
1.01	11.45	141	.06	.06	.00	204.
1.01	11.50	142	.06	.06	.00	204.
1.01	11.55	143	.06	.06	.00	204.
1.01	12.00	144	.06	.06	.00	204.
1.01	20.30	246	.02	.02	.00	72.
1.01	20.35	247	.02	.02	.00	70.
1.01	20.40	248	.02	.02	.00	70.
1.01	20.45	249	.02	.02	.00	70.
1.01	20.50	250	.02	.02	.00	70.
1.01	20.55	251	.02	.02	.00	70.
1.01	21.00	252	.02	.02	.00	70.
1.01	21.05	253	.02	.02	.00	70.
1.01	21.10	254	.02	.02	.00	70.
1.01	21.15	255	.02	.02	.00	70.
1.01	21.20	256	.02	.02	.00	70.
1.01	21.25	257	.02	.02	.00	70.
1.01	21.30	258	.02	.02	.00	70.
1.01	21.35	259	.02	.02	.00	70.
1.01	21.40	260	.02	.02	.00	70.
1.01	21.45	261	.02	.02	.00	70.
1.01	21.50	262	.02	.02	.00	70.
1.01	21.55	263	.02	.02	.00	70.
1.01	22.00	264	.02	.02	.00	70.
1.01	22.05	265	.02	.02	.00	70.
1.01	22.10	266	.02	.02	.00	70.
1.01	22.15	267	.02	.02	.00	70.
1.01	22.20	268	.02	.02	.00	70.
1.01	22.25	269	.02	.02	.00	70.
1.01	22.30	270	.02	.02	.00	70.
1.01	22.35	271	.02	.02	.00	70.
1.01	22.40	272	.02	.02	.00	70.
1.01	22.45	273	.02	.02	.00	70.
1.01	22.50	274	.02	.02	.00	70.
1.01	22.55	275	.02	.02	.00	70.
1.01	23.00	276	.02	.02	.00	70.
1.01	23.05	277	.02	.02	.00	70.
1.01	23.10	278	.02	.02	.00	70.
1.01	23.15	279	.02	.02	.00	70.
1.01	23.20	280	.02	.02	.00	70.
1.01	23.25	281	.02	.02	.00	70.
1.01	23.30	282	.02	.02	.00	70.
1.01	23.35	283	.02	.02	.00	70.
1.01	23.40	284	.02	.02	.00	70.
1.01	23.45	285	.02	.02	.00	70.
1.01	23.50	286	.02	.02	.00	70.
1.01	23.55	287	.02	.02	.00	70.
1.02	0.00	288	.02	.02	.00	70.
		SUM	32.50	31.34	1.16	108091.
			(825.)	(796.)	(29.)	(306[illegible].80)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4805.	1169.	375.	375.	108055.
CMS	136.	33.	11.	11.	3060.
INCHES		25.12	32.24	32.24	32.24
MM		638.10	818.94	818.94	818.94
AC-FT		580.	744.	744.	744.
THOUS CU M		715.	918.	918.	918.

SURFACE AREA=	0.	26.	39.	68.	105.
CAPACITY=	0.	206.	398.	927.	1785.
ELEVATION=	780.	804.	810.	820.	830.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL

SUMMARY OF DAM SAFETY ANALYSIS

PMF

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	804.00	804.00	807.10
STORAGE	206.	206.	295.
OUTFLOW	0.	0.	733.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.33	807.10	0.00	295.	732.	0.00	16.08	0.00
.34	807.15	.05	297.	761.	.25	16.08	0.00
.50	807.83	.73	319.	1294.	1.17	16.00	0.00
1.00	808.90	1.80	357.	3825.	4.25	15.92	0.00

SUMMARY OF DAM SAFETY ANALYSIS

100-YR. FLOOD

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	804.00	804.00	807.10
STORAGE	206.	206.	295.
OUTFLOW	0.	0.	733.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	806.08	0.00	263.	277.	0.00	12.83	0.00